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PROCESS AND DEVICE FOR DISINFECTING DRAINAGE WATER

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Claims

1. Process for disinfecting drainage water, in particular from horticultural operations, characterised in that percarboxylic acid is added to the drainage water.
2. Process according to claim 1 characterised in that an aliphatic percarboxylic acid is added.
3. Process according to claim 1 and 2 characterised in that peracetic acid is added.
4. Process according to one or more of the preceding claims characterised in that 0.07 to 0.30 moles percarboxylic acid per cubic metre drainage water are added.
5. Process according to one or more of the above claims characterised in that the drainage water is subjected to UVC irradiation.
6. Process according to claim 5 characterised in that the drainage water is subjected to UVC irradiation after which percarboxylic acid is added.
7. Process according to claims 5 or 6 characterised in that during irradiation, the dosage of UVC is 700 to 2000 J/l drainage water.
8. Method according to one or more of 5 to 7 characterised in that the period of irradiation is 15 to 60 minutes.

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9. Process according to one or more of claims 1 to 8 characterised in that during (a cleaning cycle of) 5 to 30 minutes, drainage water containing cleaning agent and percarboxylic acid is circulated by pumping ...
10. Process according to one or more of the preceding claims characterised in that solid particles are removed from the drainage water before disinfecting.
11. Process according to claim 10 characterised in that the solid particles are removed by means of a sand filter.
12. Device for carrying out the process according to claims 1 to 11 characterised in that the device comprises the following parts connected with each other by lines: a buffer tank for untreated drainage water, a filling pump for supplying drainage water to the reaction vessel, a metering pump for supplying percarboxylic acid solution to the drainage water, a reaction tank for the destruction of disease bacteria in the drainage water, a buffer tank for treated drainage water.
13. Device according to claim 12 characterised in that this comprises above all one or more UVC tubes for irradiating the drainage water.
14. Device according to claims 12 or 13 characterised in that this comprises above all a facility for removing solid particles from the drainage water.
15. Device according to claim 14 characterised in that the device for eliminating solid particles is a sand filter.

The invention relates to a method for disinfecting drainage water, in particular drainage water from horticultural operations. In modern horticultural operations, plants are cultivated while they root in a synthetic medium, for example rockwool. This medium is supplied with nutrient solution (i.e. water in which the necessary amount of nutrient elements are dissolved), e.g. by allowing nutrient solution to drip onto the medium. The nutrient solution contains components essential for the plants such as the nutrient elements  $\text{NH}_4^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{H}_2\text{PO}_4^-$ ,  $\text{SO}_4^{--}$ ,  $\text{Fe}^{++}$ ,  $\text{Mn}^{++}$ ,  $\text{Zn}^{++}$ ,  $\text{B}^{+++}$ ,  $\text{Cu}^{++}$  and  $\text{Mo}^{++}$ .

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In order to supply the plants continuously with the necessary amount of water and nutrient elements, excess nutrient solution is continuously added. The excess nutrient solution is caught in discharge lines and collected as so-called "drainage water" in a collecting tank in order to be recirculated to the plant beds, if necessary after adding fresh water, preferably rain water, and nutrient elements. Unless further measures are taken, it is possible for disease germs such as bacteria, moulds and viruses released by some plants to spread over the entire culture during the recirculation process and cause serious attack. For this reason, the drainage water must be disinfected before it is recirculated. This disinfection can be carried out in several ways.

Firstly by means of ozone ( $O_3$ ). This method has the disadvantage that separate ozone generators are required while measures are necessary above all to dry the gas from which the ozone is obtained, the gas is injected and maintained in the drainage water and residues of ozone are destroyed.

The second method involves heating. This has the disadvantage that combustion gases are considered environmentally harmful ( $NO_x$ ), that heat exchangers are necessary for recovering the heat and that the energy consumption is considerable.

Facilities which are based on the disinfection by means of ozone and/or heating have moreover the disadvantage that they are expensive.

The third method involves the addition of iodine ( $I_2$ ). This has the disadvantage that viruses in the drainage water are not destroyed.

The fourth method is carried out by means of UVC irradiation, the drainage water being passed along sources of UVC. In horticulture, this is effective only if the drainage water is mixed with fresh water.

The applicant has found that the disadvantages of the disinfection methods according to the state of the art can be eliminated by adding percarboxylic acid to the drainage water instead of  $O_3$ ,  $I_2$ , UVC irradiation or heat.

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Consequently, the invention relates to a method for disinfecting drainage water, in particular from horticultural operations, which is characterised in that percarboxylic acid is added to the drainage water.

Examples of percarboxylic acids suitable for application are the aliphatic and aromatic percarboxylic acids, such as peracetic acid ( $\text{CH}_3\text{CO}(\text{O})\text{OH}$ ), perpropionic acid ( $\text{C}_2\text{H}_5\text{CO}(\text{O})\text{OH}$ ), perbutyric acid ( $\text{C}_3\text{H}_7\text{CO}(\text{O})\text{OH}$ ) and perbenzoic acid ( $\text{C}_6\text{H}_5\text{CO}(\text{O})\text{OH}$ ). Since aliphatic percarboxylic acids are probably less environment-polluting than aromatic percarboxylic acids, the former are preferred. Among the aliphatic percarboxylic acids, peracetic acid is preferable in view of the fact that it has no disadvantageous influence, such as an unpleasant smell, on the environment. The amount of percarboxylic acid to be added to the drainage water can vary within wide limits. If the concentration is too low, the disinfectant effect is also too low whereas an excessively high concentration can have a negative influence on the plants when the drainage water is recirculated.

The amount of percarboxylic acid preferably added is consequently in the region of 0.07 to 0.30 moles per  $\text{m}^3$  drainage water.

For the destruction of the disease germs in the drainage water it is not alone the concentration of the percarboxylic acid which is of importance but also the period during which the germs are in contact with the percarboxylic acid. Consequently, the drainage water, after adding the percarboxylic acid, should preferably be collected in a reaction vessel and be left to stand in the latter for 15-60 minutes. It is also possible to first collect the drainage water in the reaction vessel and to then add the percarboxylic acid. In this case, the reaction vessel is advantageously a stirred vessel. The destruction of the disease germs by the percarboxylic acid in the drainage water preferably takes place at room temperature. If the surroundings are too cold, the drainage water can be heated, preferably to a temperature not exceeding  $40^\circ\text{C}$ . By adding percarboxylic acid to the drainage water, all the disease germs are completely destroyed after a certain period. The disease germs of bacteria are more rapidly destroyed than moulds and viruses. In order to eliminate moulds and viruses rapidly and completely, the drainage water is preferably subjected also to treatment with UVC radiation. UVC radiation is an electro-magnetic radiation in the ultra-violet range with a wavelength of 200-280 nanometers. The irradiation treatment can take place before or after percarboxylic acid has

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been added to the drainage water. In view of the fact that percarboxylic acid is capable of eliminating the majority of disease germs, it is appropriate to preferably add percarboxylic acid to the drainage water first and to subject it subsequently to the UVC irradiation treatment. The UVC radiation dosage is preferably between 700 and 2000 J/l drainage water during the irradiation treatment of the drainage water. In the case of a very low UVC dosage, the treatment has insufficient effect and an insufficient number of disease germs are destroyed. Too high a UVC irradiation dosage causes unnecessary energy consumption and installation costs in the case of the present method. The intensity of the UVC radiation is not the only consideration in achieving a germ-destroying effect. The period during which the drainage water is irradiated also plays an important part. It has been found that this period must preferably be in the region of 15-60 minutes in order to achieve complete disinfection of the liquid.

The aim of the present disinfection treatment is to convert the drainage water into a component for an irrigation liquid which is sufficiently sterile so that it can cause no disease in the plant material during recirculation. In order to obtain the final irrigation liquid, i.e. the liquid feed, the disinfected drainage water is mixed with fresh water, preferable rain water, and plant nutrient substances. This mixing process can be carried out in such a way that disinfected drainage water is first mixed with fresh (rain) water and subsequently nutrient substances are added. Whenever this is the case, the drainage water - after the disease germs have been destroyed at least partially by means of percarboxylic acid, can be first mixed with fresh (rain) water and the mixture then treated with UVC radiation. This latter method is less effective since the salts present in the drainage water absorb UVC radiation, as a result of which the radiation is capable of penetrating less deeply into the drainage water than is desired and has thus a reduced effect. By adding (rain) water, which results in a very low salt content, the disinfection effect of the UVC radiation is improved. The amount of fresh (rain) water mixed into the drainage water before it is recirculated to the plant material depends on the water absorption of the plants and the possible loss by evaporation during the recirculation process. This amount can vary within wide limits and is within the region of 0.5 to 10 m<sup>3</sup> (rain) water per m<sup>3</sup> drainage water, a range of 1.5 to 3 m<sup>3</sup> (rain) water per m<sup>3</sup> drainage water being preferably chosen in practice. The drainage water may contain solid particles as a result of its

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contact with the plant material and the substrate in which the latter has taken root. This is preferably removed from the drainage water before it is subjected to the present disinfection treatment. This elimination can take place in any desired manner such as settling out, filtration, centrifuging etc. Advantageously, a sand filter is used to achieve this aim. This has the advantage that the drainage water is not mixed with rain water during the UVC treatment: a larger volume of drainage water can be disinfected per unit of time.

The invention also relates to a device for the method described. Such a device comprises the following parts which are connected by pipelines:

1. A buffer tank for untreated drainage water.
2. A filling pump for supplying drainage water to the reaction tank.
3. A metering pump for supplying percarboxylic acid solution to the drainage water.
4. A reaction vessel for destroying disease germs in the drainage water.
5. A buffer tank for treated drainage water.

Preferably, the device according to the present invention also comprises the following parts:

1. One or more UVC lines for irradiating the drainage water or the mixture of drainage water and (rain) water supplied.
2. A device for the elimination of solid particles from the drainage water, preferably a sand filter.

The invention will now be explained in further detail by way of the following diagrammatic representation to which the invention is in no way limited. Valves, expansion tanks, measuring and control equipment is not shown in this drawing. Untreated drainage water is passed from a horticultural operation (not shown) via line 1 to a buffer tank 2. From the buffer tank 2, the drainage water is passed through line 3, a filling pump 4 and line 5 to a sand filter 6 in which solid particles are removed from the drainage water. From filter 6, the drainage water is removed via line 7. Via line 8, a percarboxylic acid solution is injected into the drainage water through a dosage pump 9 via line 10. The mixture of drainage water and percarboxylic acid solution

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is passed via line 11 to the reaction vessel 12 in which the drainage water is disinfected at least partly. The drainage water is passed by pump 15 through line 13 from the reaction vessel.

It is mixed with fresh rain water introduced via line 14 subsequent to which the mixture of drainage and rain water is passed through one or more UVC tubes. While the mixture passes through the tubes 16, it is virtually completely disinfected by the UVC radiation which exerts its effect in line 16. The mixture is passed through line 17 to the buffer tank 18 for treated drainage water plus fresh make-up water and recirculated through line 19 to the plant substrates (not shown). If necessary, a solution of plant nutrients can be added to the buffer tank 18 or line 19.

When no further rain water is added, the drainage water can be recirculated via the sources of UVC to the reaction vessel. Mixing of the drainage water with rain water takes place whenever the nutrient solution is prepared.

#### Example

The bacteria *Escherichia coli* and *Pseudomonas* sps and the Fungus *fusarium oxysporum* are added to drainage water from the cultivation of roses. The bacteria and fungus concentration was 100,000 and 10,000 per ml respectively. The drainage water also contained the nutrients detailed in the following table 1.

Table I

<u>Main Elements</u>	<u>Concentration (mmole/l)</u>
$\text{NH}_4^+$	1,25
$\text{K}^+$	5,00
$\text{Ca}^{++}$	3,50
$\text{Mg}^{++}$	0,75
$\text{NO}_3^-$	11,00
$\text{H}_2\text{PO}_4^-$	1,25
$\text{SO}_4^{--}$	1,25
<u>Trace elements</u>	<u>Concentration (micromole/l)</u>
$\text{Fe}^{++}$	25,0
$\text{Mn}^{++}$	5,0
$\text{Zn}^{++}$	3,5
$\text{B}^{+++}$	20,0
$\text{Cu}^{++}$	0,75
$\text{Mo}^{++}$	0,50

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A quantity of 2.2 m<sup>3</sup> drainage water with the composition detailed above is treated in a device as illustrated in the diagrammatic representation with the method according to the invention. For this purpose, it is pumped by means of pump 4 from tank 2 over sand filter 6 to reaction vessel 12 while 200 ml peracetic acid solution with a concentration of 66 g/l are injected into it per m<sup>3</sup> drainage water by means of pump 9. In reaction vessel 12, the mixture is allowed to react for 1 hour. At the same time, the mixture is passed over four UVC lines with a recorded capacity of 55 W each. The UVC dosage is 770 J/l drainage water and the treatment time is 60 minutes. Samples are taken regularly and the germ count is determined. The treated drainage water is collected in a buffer tank from which it is passed to the plant substrate after the necessary nutrient substances plus rain water have been added. The reaction product of peracetic acid (acetic acid) appears to be harmless to the plants. The destruction of the bacteria and mould by the treatment with peracetic acid (PAA) alone on the one hand and by a combined PAA and UVC treatment on the other hand is shown in the following table 2.

Table II

Effect of disinfection treatment

Diseased germ	PAA Treatment		PAA/UVC Treatment	
	Time required	Destruction*(%)	Time required	Destruction*(%)
Escheriachiocoli	8 min.	99.99	8 min.	99.99
Pseudomonas sps	8 min.	99.99	8 min.	99.99
Fusarium Oxysporum	60 min.	85	44 min.	99.99

\*The destruction is expressed as a percentage of the original number of disease germs added to the drainage water.



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Table II shows that practically complete disinfection of the drainage water from horticultural operations can be achieved by means of the method according to the invention within the treatment period applied. As a result worth noting it is also found that the UVC transmission percentage increased from 35% initially to 50% at the end of the treatment.

In the case of a method and device in accordance with the invention, it is possible for moulds to grow with the concentration of percarboxylic acid used; these may cause blockages. Also, a moisture deposit can form on the so-called quartz glass of the UVC line. These difficulties can be eliminated by (as will be shown below) by making use of a "dead" amount of drainage water present in the device, i.e. making use of part of the drainage water which remains behind in the reaction vessel which in practice amounts to some 10% of the net amount of drainage water treated.

The growth of fungus can be combatted before beginning the actual disinfection of the drainage water by introducing percarboxylic acid into the reaction vessel and subsequently acidifying the mixture of drainage water and percarboxylic acid with water to a pH of 1.5 to 2.5 thus forming the so-called residual water. After some time, the residual water is pumped round or stirred and passed along the UVC tubes during which process the acidic water removes the deposit on the quartz tubes. This cleaning cycle can be carried out over 5 to 30 minutes during the actual 5 to 40 disinfection cycles. Whenever a cleaning cycle is completed, the actual disinfection cycle can be started by filling the reaction vessel with drainage water. It should be noted that no percarboxylic acid then needs to be added. The amount of percarboxylic acid used for disinfection corresponds to that used during the cleaning cycle.

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